

**We Claim:**

1. A device for monitoring activity of carbon in a heat treating atmosphere comprising  
a processor to generate a computed activity of carbon value for the gas atmosphere as a function of temperature, partial pressure of oxygen, and carbon monoxide content of the gas atmosphere, and without determining a carbon dioxide content of the gas atmosphere, and  
an output terminal coupled to the processor to output the computed activity of carbon value.
2. A device according to claim 1 wherein the processor includes a comparator to compare the computed activity of carbon value to a selected set point and generate a deviation, and further including an output for the deviation.
3. A device according to claim 2 wherein the output is coupled to a controller for the atmosphere.
4. A device according to claim 2 or 3 and further including an input for recording the selected set point from an operator.
5. A device according to claim 1 wherein the output is coupled to a device for displaying the computed activity of carbon value.
6. A device according to claim 1 wherein the output is coupled to a device for recording the computed activity of carbon value.
7. A device according to claim 1 and further including an input adapted to receive an electrical signal generated by at least one sensor indicating either the partial pressure of oxygen or the temperature of the atmosphere, and wherein the processor processes the electrical signal to generate the computed activity of carbon value.

8. A device according to claim 1  
and further including an input adapted to be  
coupled to a temperature sensor that generates an  
electrical signal that varies according to the  
5 temperature of the atmosphere, and

wherein the processor processes the electrical  
signal to generate the computed activity of carbon value.

9. A device according to claim 1  
and further including an input adapted to be  
10 coupled to an oxygen sensor that generates an electrical  
signal that varies according to the temperature and  
partial pressure of oxygen of the atmosphere, and

wherein the processor processes the electrical  
signal to generate the computed activity of carbon value.

10. A device according to claim 1  
wherein the processor also generates an  
oxidation alarm based upon the partial pressure of oxygen  
and temperature of the gas atmosphere.

11. A device according to claim 1  
and further including an input coupled to the  
20 processor and adapted to receive an electrical signal  
that varies according to the carbon monoxide content of  
the gas atmosphere, and

wherein the processor processes the electrical  
25 signals to generate the computed activity of carbon  
value.

12. A device according to claim 11  
wherein the electrical signal is generated  
based upon analysis of a gas atmosphere sample.

13. A device according to claim 11  
wherein the electrical signal is set based  
30 upon a known carbon monoxide content.

14. A system for monitoring a gas heat  
treating atmosphere comprising  
35 a processing element to derive a process

variable indicative of an activity of carbon value for the gas atmosphere derived from at least one sensor placed *in situ* in the gas atmosphere, and

an output for the process variable.

5           15. A system according to claim 14 wherein the output is coupled to a device that displays the process variable.

          16. A system according to claim 14 wherein the output is coupled to a device that  
10 records the process variable.

          17. A system according to claim 14 wherein the output is coupled to a device that generates the gas atmosphere.

          18. A spherodize annealing system comprising  
15 a heat treating furnace,  
an atmosphere source for supplying a preselected gas atmosphere to the furnace,  
a heat source to maintain the preselected gas atmosphere inside the furnace at a preselected  
20 temperature,

an oxygen sensor located *in situ* in the furnace in contact with the preselected gas atmosphere, the oxygen sensor providing a first electrical input that varies according to oxygen content of the preselected  
25 atmosphere,

a temperature sensor located *in situ* in the furnace in contact with the preselected gas atmosphere, the temperature sensor providing a second electrical input that varies according to temperature of the  
30 preselected atmosphere,

a processor to generate a computed activity of carbon value for the preselected atmosphere as a function of the first and second electrical inputs.

          19. A system according to claim 18  
35 and further including an output for the

computed activity of carbon value.

20. A system according to claim 19  
wherein the output is coupled to a device for  
displaying the computed activity of carbon value.

5 21. A system according to claim 19  
wherein the output is coupled to a device for  
recording the computed activity of carbon value.

22. A system according to claim 19  
wherein the output is coupled to a controller  
10 for the atmosphere source.

23. A system according to claim 18  
wherein the processor includes a comparator to  
compare the computed activity of carbon value to a  
selected set point and generate a deviation, and  
15 further including an output for the deviation.

24. A system according to claim 23  
wherein the output is coupled to a controller  
for the atmosphere source.

25. A spherodize annealing system comprising  
20 a heat treating furnace,  
an atmosphere source for generating a  
preselected gas atmosphere and supplying the preselected  
gas atmosphere to the furnace,

25 a heat source to heat the preselected gas  
atmosphere sufficiently to create a two phase region  
inside the furnace,

30 a processor to generate a computed activity of  
carbon value for the gas atmosphere as a function of  
temperature, partial pressure of oxygen, and carbon  
monoxide content of the gas atmosphere, and without  
determining a carbon dioxide content of the gas  
atmosphere,

an output terminal coupled to the processor to  
output the computed activity of carbon value, and

35 a controller coupled to the output terminal

and the atmosphere source to control generation of the gas atmosphere according to the computed activity of carbon value.

26. A system according to claim 25  
5 wherein the processor includes a comparator to compare the computed activity of carbon output to a set point value and generate a control signal based upon the comparison,

10 wherein the output terminal outputs the control signal to the controller, and

wherein the controller controls generation of the gas atmosphere based upon the control signal.

27. A system according to claim 25  
15 wherein the selected activity of carbon value varies as a function of temperature.

28. A method for monitoring a heat treating atmosphere comprising the steps of  
generating a computed activity of carbon value of the heat treating atmosphere as a function of  
20 temperature, partial pressure of oxygen, and carbon monoxide content of the heat treating atmosphere, and without determining a carbon dioxide content of the heat treating atmosphere, and

using the computed activity of carbon value.

25 29. A method according to claim 28 wherein the using step includes controlling the heat treating atmosphere based, at least in part, upon the computed activity of carbon value.

30 30. A method according to claim 29 wherein the using step includes recording the computed activity of carbon value.

31. A method according to claim 29 wherein the using step includes displaying the computed activity of carbon value.

35 32. A method for monitoring a heat treating

atmosphere comprising the steps of

deriving from at least one sensor placed *in situ* in the heat treating atmosphere a process variable indicative of the activity of carbon in the heat treating atmosphere, and

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using the process variable.

33. A method according to claim 32

wherein the using step includes controlling the heat treating atmosphere based, at least in part, upon the process variable.

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34. A method according to claim 32

wherein the using step includes recording the process variable.

35. A method according to claim 32

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wherein the using step includes displaying the process variable.

36. A method for performing spheroidize annealing comprising the steps of

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generating a gas atmosphere and supplying the gas atmosphere to a furnace,

heating the gas atmosphere in the furnace sufficiently to create a two phase region,

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generating a computed activity of carbon value for the gas atmosphere as a function of temperature, partial pressure of oxygen, and carbon monoxide content of the gas atmosphere, and without determining a carbon dioxide content of the gas atmosphere, and

controlling the gas atmosphere according to the computed activity of carbon value.

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37. A method according to claim 36

and further including the step of comparing the computed activity of carbon output to a selected activity of carbon value and generate a control signal based upon the comparison, and

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wherein control step controls the gas

atmosphere based upon the control signal.

38. A method according to claim 37  
wherein the selected activity of carbon value  
varies as a function of temperature.

5 39. A method for performing spheroidize  
annealing comprising the steps of  
generating a gas atmosphere and supplying the  
gas atmosphere to a furnace,  
heating the gas atmosphere in the furnace  
10 sufficiently to create a two phase region,  
sensing oxygen content with an oxygen sensor  
placed in situ in the furnace to provide a first  
electrical output that varies according to oxygen content  
of the gas atmosphere,  
15 sensing temperature with a temperature sensor  
placed in situ in the furnace to provide a second  
electrical output that varies with temperature,  
computing an activity of carbon value based  
upon the first and second electrical outputs, and  
20 controlling the gas atmosphere according to  
the computed activity of carbon value.

40. A method according to claim 39  
and further including the step of comparing  
the computed activity of carbon to a selected activity of  
25 carbon value and generate a control signal based upon the  
comparison, and  
wherein control step controls the gas  
atmosphere based upon the control signal.

41. A method according to claim 40  
30 wherein the selected activity of carbon value  
varies as a function of temperature.

42. A method for determining a partial  
pressure of carbon monoxide in a gas atmosphere  
comprising a mixture of nitrogen and either an  
35 endothermic atmosphere or methanol, the method comprising

the steps of

supplying the gas atmosphere at a fixed flow rate into a furnace,

5 deriving from an oxygen sensor placed in situ in the furnace a sensed partial pressure of oxygen in the furnace,

deriving from a temperature sensor placed in situ in the furnace a sensed temperature in the furnace,

10 deriving, without using a carbon monoxide sensor outside the furnace, a partial pressure of carbon monoxide as a function of the sensed partial pressure of oxygen and the sensed temperature.